5 March 2009

FIRST ANNUAL REPORT ON NASA RESEARCH OPPORTUNITIES IN SPACE AND EARTH SCIENCES 2007 #NNX08AN81G

« APPLICATION OF SATELLITE DATA TO ENHANCE FAA TACTICAL FORECASTS OF CONVECTIVE INITIATION AND GROWTH »

April 30, 2008 – March 1, 2009

This report outlines the work accomplished in the first year of the contract by the combined efforts of the project team, consisting of scientists and engineers from the University of Alabama, Huntsville (UAH), Massachusetts Institute of Technology Lincoln Laboratory (MIT-LL), and NASA Short-term Prediction Research and Transition Center (NASA SPoRT).

Note: Year 1 funding was received at UAH July 15, 2008 and funding was received at MIT-LL in January 2009.

Research Activities

a) Database Development

UAH has developed a multi-parameter database that will be developed in real-time using the current SATCAST parameters, as well as data from RUC model fields and NASA data from the A-Train satellite constellation. Figure 1 is a flow chart of the operational system and the various datasets this system that will be collected in Table 1. These data will begin processing and collecting data over the 2009 convective season over the US (with plans to include Hawaii and Puerto Rico before the beginning of the summer 2009). This system will be an end-to-end data collection system, monitoring pre-convective environments (using AIRS profiles and precipitatble water as observed from NASA data) to mature convective systems. This end-to-end monitoring will allow for real-time verification statistics. The system will be operational by the end of March 2009.

Table 1. Various data to be collected for each satellite object (RUC fields in bold).

SATCAST Interest Fields	**Surface based CAPE**
Surface Pressure	**Convective Inhibition**
2 meter Temperature	Precipitable Water
2 meter Dewpoint Temperature	**Model derived precipitable water**
2 meter specific humidity	WSR-88D Radar reflectivity
Surface Lifted Index	

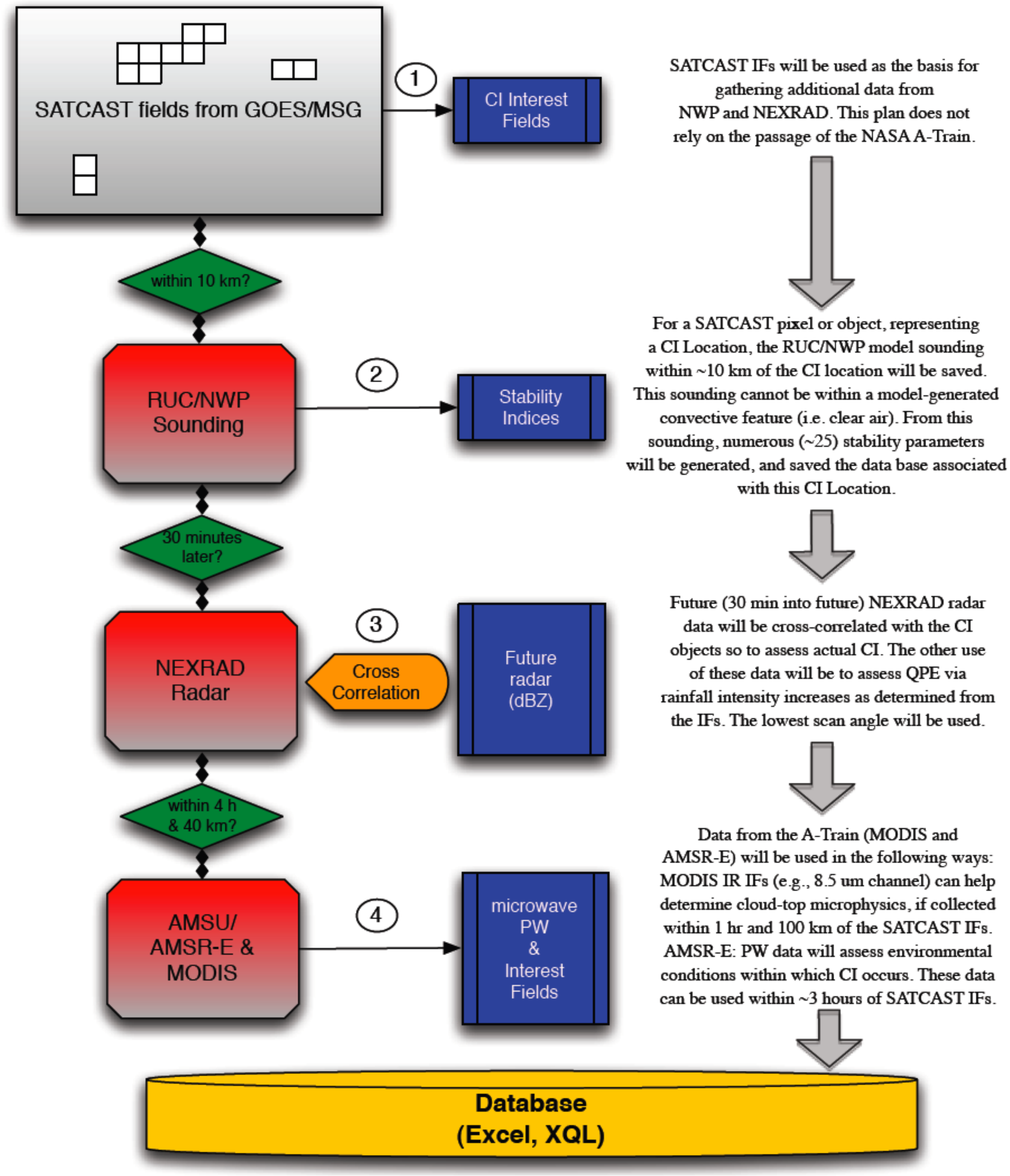

Figure 1. Data processing flowchart for ROSES 2007.

Using data from the NASA African Monsoon Multidisciplinary Analyses (NAMMA) experiment over the Cape Verde Islands off the western African coast, UAH will explore the use of Meteosat Second Generation (MSG) data and the increase in spectral channels for use within the SATCAST system with the approach of GOES-R. NAMMA provides affords access to a NASA S-band radar to be used for verification purposes. A recent study by Mecikalski et al. (2009) has found that additional MSG spectral channels can provide additional, non-redundant information (Table 1). This information will be used when exploring the use MSG data within this study. Much of this MSG work is being written up in two papers, Mecikalski et al. (2009a,b).

Table 1: Retained MSG interest fields for nowcasting CI. Here, “SD” is standard deviation. See text for description.

Cloud Depth	**Mean**	**SD**
6.2–10.8 μm difference	-22.05°	11.27°
10.8 μm T_B	252.02° K	16.79°
6.2–7.3 μm difference	-9.52°	5.94°
12.0–10.8 μm difference	-1.08°	1.15°
0.6 μm reflectance (for optical depth)	0.305	0.173
0.8 μm reflectance (for optical depth)	0.360	0.188
30-min Trend 0.6 μm reflectance	0.024	0.087
30-min Trend 0.8 μm reflectance	0.021	0.087
Cloud-top Glaciation	**Mean**	**SD**
(8.7-10.8 μm)–(10.8-12.0 μm) “Tri-Channel”	-1.29°	1.94°
30-min Trend Tri-Channel	1.59°	1.96°
8.7–10.8 μm difference	-0.21°	1.55°
15-min Trend Tri-Channel	0.87°	2.02°
3.9–10.8 μm difference	-0.79°	0.41°
15-min Trend 3.9–10.8 μm difference	0.30°	0.24°
1.6 μm reflectance	0.173	0.091
30-min Trend 1.6 μm reflectance	-0.040	0.069
3.9 μm reflectance	0.050	0.038
Updraft Strength	**Mean**	**SD**
30-min 10.8 μm T_B Trend	-18.04°	13.54°
30-min Trend 12.0–10.8 μm difference	0.26°	1.17°
15-min Trend 12.0–10.8 μm difference	0.18°	1.05°
15-min 10.8 μm T_B Trend	-11.14°	9.44°
30-min Trend 8.7–10.8 μm difference	1.33°	1.54°
HRV Cloud Texture	n/a	n/a

Once all the data has been collected over the course of approximately 1 year, the data will be analyzed using a decision tree based, artificial intelligence system called Random Forest (Breiman 2001). Research by NCAR RAL has shown that Random Forest can be used as a means by which importance can be deduced from the votes of each decision tree within the system. While the database is being compiled, more research by UAH will be performed to further substantiate this claim so that when database processing begins, confidence within the Random Forest system will be high and appropriate weights can be applied to each interest field.

b) Object Tracking

Two main goals of this effort as related to the NASA ROSES proposal are to: (a) development an improved method of tracking storms such that the physical characteristics of satellite-observed convection can be optimally represented towards meeting the goals of the ROSE effort (refer to Figure 2 as an example), (b) demonstrate the value of 5-min MSG imagery, so-called "rapid scan" data, and (c) to develop a "replacement" approach for the MAMVs approach for tracking growing/developing cumuli. The solution to these approaches are interrelated, in that via the method of (i) identifying and treating a cumulus cloud as an "object" of conjoined and related pixels, (ii) tracking objects over time as a means of understanding the character of the whole cloud, and (iii) monitoring object properties as related to cumulus cloud behavior, one needs 5-minute imagery. In effect, when studying and evolution and physics of cumulus clouds, the important time and space scales are 1-3 km and 5-15 minute (see REF). As it is, rapid scan data effectively matches the spatial scales provided routinely by MSG (namely, MSG). This section outlines the "object tracking" work done as a component of this study, and how it can be used to replace the MAMV method. The MAMVs approach suffers from two limitations which hamper its use in the "operational" environment: (1) The MAMVs method requires "background" NWP information for providing a first guess on the retrieved winds, as well as in the QA/QC step for removing erroneous winds (see Bedka et al. 2005), and (2) The MAMVs method is computationally expensive, often requiring 10's of minutes of processing within SATCAST, especially when large numbers of winds are generated [O(10^5)] over large geographical domains (e.g., 100° of longitude by 30° of latitude).

A few important notes will be made before describing the object tracking method: Certainly, use of 5-min rapid scan data are valuable for tracking small (≤3 km) scale features in MSG data, however, 5-min time-differences of IR channel trends are recognized as having low signal to noise ratios, compared to using 15-min time differences. At this time, all research on defining new and updated CI interest fields from MSG data utilize 15-min data because it is felt that time-differencing provides better signals across a population of cumulus clouds [MSG2 satellite was not operating in rapid scan mode during COPS, and hence rapid scan data were not available for that portion of this study.] Also, the MAMVs approach to tracking cumuli is generally quite useful, and only fraught with tracking errors when considerable vertical wind shear exists within the pre-convective environment. Mecikalski et al. (2008) quantifies this error, in terms of GOES 4-km pixel errors as a function of wind shear (i.e. large wind direction changes with height that cause the wrong pixel to be used when computing single and two-channel time trends).

To overcome the definicies of the MAMV method and the current pixel based approach, two approaches are currently being investigated. Since the current GOES satellite has a temporal resolution over CONUS of 15 minutes, tracking of the clouds becomes difficult. One approach is the use of the Warning Decision Support System (WDSS-II) to track objects. This approach as documented by Lakshmanan et al. (2007) uses radar objects and a cross-correlation technique to track the motion. Research is currently occurring at UAH as the whether this technique can be applied to satellite data. Another approach, which UAH is currently exploring, is taking all of the MAMV's over an entire object, and using the average speed and direction from the MAMV's over the object. By the end of March 2009, a decision will be made as to which approach will be used and applied to this effort for both the current GOES and MSG to ensure that the selected tracking system will operated with both satellites.

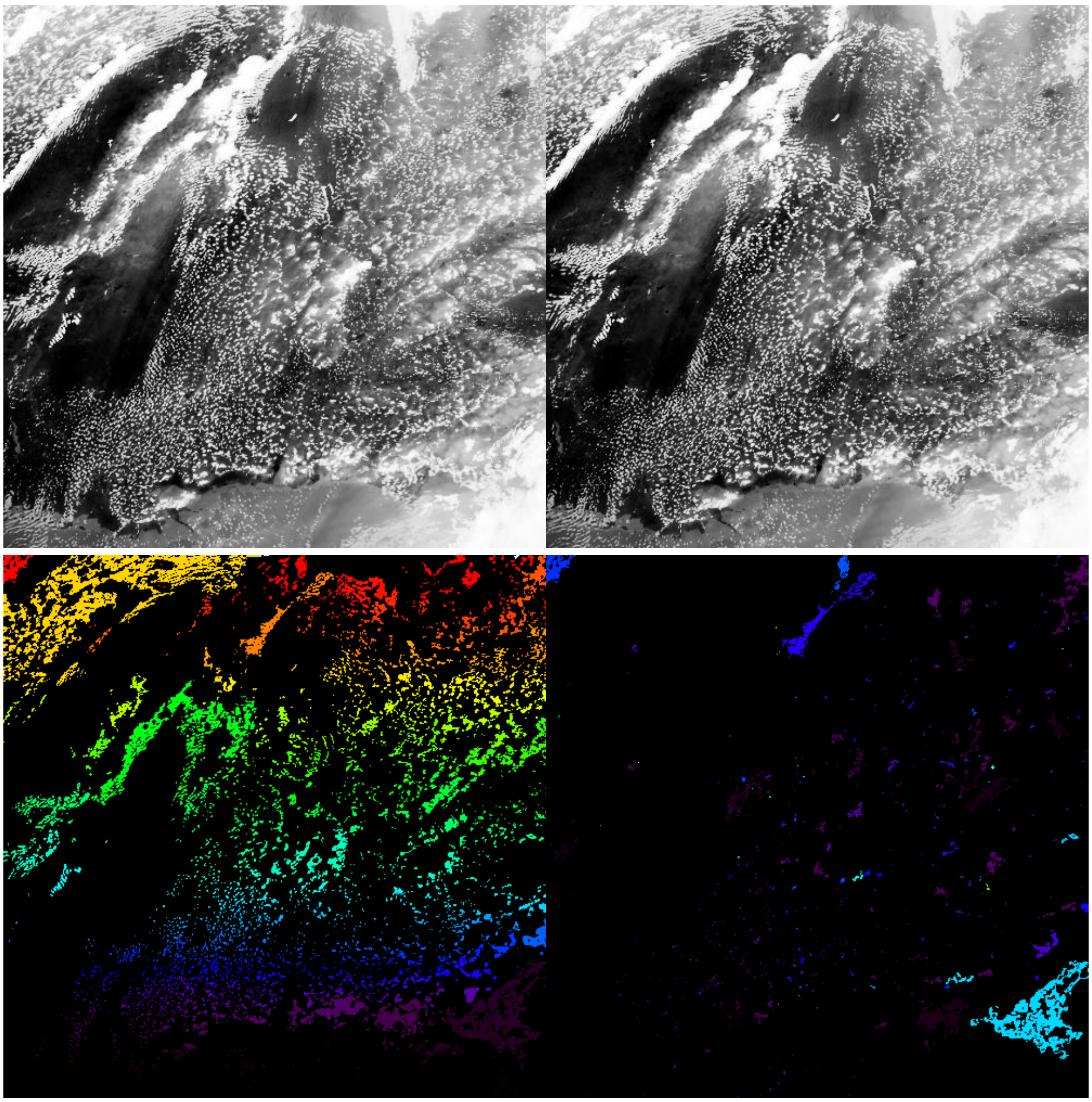

Figure 2: Demonstration of the object-tracking algorithm with rapid scan (5-min) data at the MSG resolution. Upper-left (2200 UTC) and upper-right (2205 UTC) images are enhanced 10.8 μm data, respectively. Lower-left and lower-right images valid at 2205 UTC show the identified objects (via the above algorithm) and the time trends of 10.8 μm T_B. The colors in the lower-left image highlight the numbering of all objects, whereby the warmer colors are numbers decreasing to 0 in the upper-left, with dark purples being the highest numbered objects.

c) A-Train Analysis

Analysis on pre-convective environmental data as observed from NASA datasets has begun at UAH. One UAH Graduate student is performing this work. This will determine whether these data can be useful within the SATCAST system as a predictor field to estimate whether convective initiation (CI) false alarms can be reduced, and as an indictor for severe storm severity. The process design for this work revolves around the use of a convective cloud mask (Berendes et al. 2008) to be applied to GOES data, to highlight areas of growing cumulus around the time of a local NASA A-Train overpass. Cases will be selected over the regions of interest where CI did occur in the future. Then using Cloudsat, CALIPSO and AIRS datasets, determine whether these datasets can be used within a predictive capability for nowcasting CI. Work has been started processing the convective cloudmask on data starting in March 2008 and processing continues thru the convective season through 2008. By late summer 2009, this work will be much farther along, with more to be reported by Year 2.

Meeting and Coordination

1. A kick-off teleconference with UAH, MIT-LL, and NASA SPoRT was conducted on May 28, 2008.
2. Dr. Haig Iskendarian from MIT-LL visited UAH and NASA SPoRT on October 21-22, 2008.
3. Attended and presented the ROSES 2007 plan at the NASA Applied Sciences Program Review on November 17-20, 2008.
4. A teleconference was conducted on January 28, 2009. A discussion occurred on the use of the information from the database and its applicability to the MIT-LL CoSPA system.

References

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